

## PATENT SPECIFICATION

DRAWINGS ATTACHED

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## COMPLETE SPECIFICATION

### Improvements in or relating to operating circuit arrangements for electromagnetic devices.

- We, GRUNDIG E.M.V. ELEKTRO-MECHANISCHE VERSUCHSANSTALT, Inh. MAX GRUNDIG, a German corporate body, of Kurgartenstrasse 37, Fuerth/Bayern, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, the method by which it is to be performed, to be particularly described in and by the following statement:—
- 10 This invention relates to an operating circuit arrangement for electromagnetic devices and in particular for transistor-controlled electromagnetic devices.
- It is known that the operation of solenoid valves, magnetic clutches and like electromagnetic devices can be accelerated by applying to the operating coil of the device to be actuated, at the moment of bringing it into operation, an increased voltage which, after the operation has been effected, is reduced to the normal working voltage for the device or to a lower voltage. If the voltage control is carried out by means of relays, it is easily possible at first to use double the working voltage as a supply voltage and subsequently to reduce this voltage to the normal working voltage by connecting a resistor in series with the supply. If the control is to be effected by means of transistors, however, this procedure requires that transistors are used, the inverse voltage of which amounts to double the working voltage.
- The invention discloses a means which renders it possible to employ transistors of which the inverse voltage is equal to the normal supply voltage.
- According to the present invention there is provided an operating circuit arrangement for an electromagnetic device wherein the operating coil of said device is connected across a direct voltage source in series with the emitter/collector path of a transistor and in series with a diode poled to allow current to flow from said source through said coil and wherein a capacitor arranged to be charged from said source through said diode is also arranged when said transistor becomes conductive to be connected by way of the emitter/collector path of a second transistor so that the voltage thereon reverse biases said diode and is added to that of said source to cause current to pass through said coil.
- In this case one terminal of the capacitor may be connected both to the anode of the diode leading to one pole of the source of working voltage and to the device to be controlled and its other terminal may be connected to the collector of the second transistor, which is returned through a resistor to the other pole of the source of working voltage. The base of the second transistor is controlled in accordance with the condition of conduction of the transistor connected in the circuit of the device to be controlled. A certain disadvantages of this circuit arrangement is that the inductive voltage peak, occurring when the controlled device is disconnected, cannot be satisfactorily checked. It would, for this purpose, be possible to connect a diode in parallel with the controlled device. This would involve a delayed release, however, which cannot in every case be accepted.
- It is therefore more favourable to connect one terminal of the capacitor to the anode of the diode, the cathode of which may appropriately be connected by way of the series combination of a resistor and the controlled device to one pole of the source of working voltage, and also to the collector of the first transistor, and the other terminal of the capacitor to the emitter of the second transistor and, through the series combination of a second diode and a resistor, to the other pole of the source of working voltage. The emitter and base of the second transistor are bridged by a resistor which, with a further resistor returned to the other pole of the source, forms a voltage divider which, when

the first transistor becomes conducting, also makes the second transistor conducting. The on-load voltage can be limited to half the working voltage by the resistor connected in series with the device, so that the energy stored at the moment of disconnection is considerably lower. In addition, the energy released in the member to be operated when the first transistor is cut off can immediately re-charge the capacitor so that energy recovery occurs.

Two examples of embodiments of the invention will be explained in more detail below with reference to the drawing, comprising Figures 1 and 2 in both of which the same reference numerals are used for like parts.

In the circuit shown in Figure 1, the device to be controlled — a solenoid valve MV — is connected to the neutral conductor through the emitter-to-collector path of a first transistor  $T_1$  and to the negative pole of a -24V source of working voltage through a diode  $D_1$ . Also connected to this pole of the source of working voltage is the emitter of a second transistor  $T_2$  of which the collector is connected through a resistor  $R_1$  to the other pole of the voltage source and in addition to the one terminal of a capacitor C, the other terminal of which leads to the anode of the diode  $D_1$ . The base of this second transistor is connected to the collector of the first transistor  $T_1$  through a resistor  $R_2$ ; another resistor  $R_3$  serves as a base-to-emitter leak resistance.

When the transistors  $T_1$  and  $T_2$  are cut off, the capacitor C becomes charged with the polarity shown through the diode  $D_1$  and the resistor  $R_1$ . This state changes as soon as the actuating voltage is applied to the base of the transistor  $T_1$ . As a result of this applied voltage the transistor  $T_1$  becomes conducting and also sets the transistor  $T_2$  into the conducting state through the resistor  $R_3$ . The diode  $D_1$  is thus reverse biased and the voltage appearing on the capacitor is added to the supply voltage and becomes effective at the solenoid valve MV, that is to say the operation of the solenoid valve is accelerated. On the discharge of the capacitor, the voltage drops and diode  $D_1$  again becomes conductive so that the solenoid valve is run at the normal voltage after the capacitor discharge is terminated.

In the embodiment of the invention which is shown in Figure 2, the one terminal of a capacitor C is connected to a circuit leading from the collector of a first transistor  $T_1$  and to the anode of the diode  $D_1$  of which the cathode is connected through a resistor  $R_4$  and a solenoid valve MV to be controlled to the negative pole of a -24V source of working voltage, and its other terminal is connected to the emitter of a second transistor  $T_2$ . The emitter of the transistor  $T_2$  is

also connected, through the series combination of a second diode  $D_2$  and a resistor  $R_5$ , to the neutral conductor of the source of working voltage. Furthermore, there is connected from the transistor base to the neutral line a voltage divider formed by the series combination of a resistor  $R_6$  and a resistor  $R_7$ , which form a voltage divider to the tapping of which the base of the transistor is connected. The collector connection of transistor  $T_2$  is taken to the junction point of resistor  $R_6$  and the solenoid valve MV.

With transistors  $T_1$  and  $T_2$  cut off, the capacitor C can be charged through the solenoid valve MV, the resistor  $R_4$ , the diodes  $D_1$  and  $D_2$  and the resistor  $R_5$ . When the transistor  $T_1$  becomes conducting through the application to its base of an actuating voltage applied at terminal E, the terminal of the capacitor C carrying the negative potential becomes connected to the neutral conductor. There is thus applied to the base of transistor  $T_2$  from voltage divider  $R_6$ ,  $R_7$  a voltage which causes the transistor to become conducting. Thus capacitor C is now connected in parallel with the resistor  $R_4$  and the diode  $D_1$  so that here, too, the voltage appearing on the capacitor C is added to the supply voltage and becomes effective on the solenoid valve MV. The solenoid valve is thus operated with double the supply voltage at the moment of energization.

As soon as the capacitor C is discharged, the voltage drop on the resistor  $R_4$  disappears so that the transistor  $T_2$  returns to the cut-off condition. The solenoid valve MV receives its operating current through the transistor  $T_1$ , the diode  $D_1$  and the resistor  $R_4$ . The on-load voltage of the solenoid is reduced to a lower value, for example half the working voltage, by the series resistor  $R_4$  so that at the moment of disconnection the stored electrical energy is negligible. When transistor  $T_1$  is cut off, the energy released from the solenoid recharges the capacitor C through the resistor  $R_4$ , the diodes  $D_1$  and  $D_2$  and the resistor  $R_5$ ; thus this energy is not wasted. Care must be taken to ensure that the resistor  $R_5$  has a value such that the current flowing through it remains below the holding current for the solenoid valve.

#### WHAT WE CLAIM IS:—

1. An operating circuit arrangement for an electromagnetic device wherein the operating coil of said device is connected across a direct voltage source in series with the emitter/collector path of a transistor and in series with a diode poled to allow current to flow from said source through said coil and wherein a capacitor arranged to be charged from said source through said diode is also arranged when said transistor becomes conductive to be connected by way

of the emitter/collector path of a second transistor so that the voltage thereon reverse biases said diode and is added to that of said source to cause current to pass through said coil.

- 5 2. A circuit arrangement in accordance with claim 1 wherein said diode, said coil and the emitter/collector path of the first said transistor are connected in series in the order stated from a first to a second pole of said source, the emitter/collector path of said second transistor and a resistor are connected in series in the order stated from said first to said second pole, said capacitor is  
10 connected from the junction of said diode with said coil to the junction of said second transistor with said resistor and the base of said second transistor is connected to the tapping of a voltage divider formed by  
15 resistors connecting said first pole to the junction of said coil with said first transistor.  
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3. A circuit arrangement in accordance with claim 1 wherein said coil, a resistor, said diode and the emitter/collector path  
25 of first said transistor are connected in series in the order stated from a first to a second pole of said source, said capacitor, a second diode and a resistor are connected in series in the order stated in parallel with the

emitter/collector path of said first transistor, 30 the emitter/collector path of said second transistor is connected from the junction of said coil with first said resistor to the junction of said capacitor with said second diode, and the base of said second transistor is connected 35 to the tapping of a voltage divider comprising resistors connected in series between the junction of said capacitor with said second diode to said second pole.

4. An operating circuit arrangement for 40 an electromagnetic device substantially as described with reference to Figure 1 of the drawing.

5. An operating circuit arrangement for 45 an electromagnetic device substantially as described with reference to Figure 2 of the drawing.

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COMPLETE SPECIFICATION  
This drawing is a reproduction of  
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FIG. 1

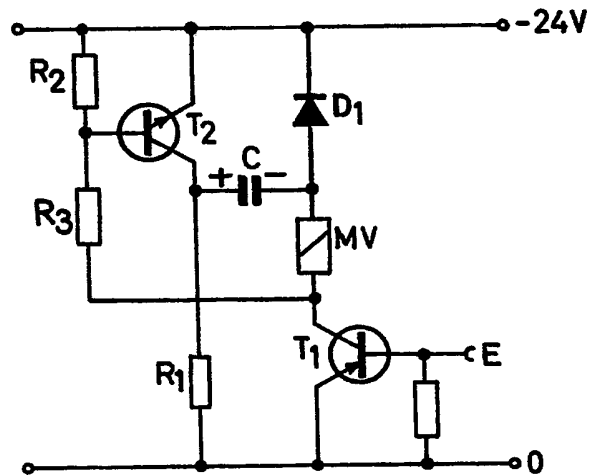


FIG. 2

